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# Gender Difference in Teachers' Mathematical Knowledge for Teaching in the Context of Single-Sex Classrooms

**Ramzi F. Haroun · Dicky Ng · Faisal A. Abdelfattah · Misfer S. AlSalouli**

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**Abstract** This study examines gender differences of teachers on their mathematical knowledge for teaching in the context of single-sex classrooms in Saudi Arabia. A translated version of the Mathematical Knowledge for Teaching (MKT) instrument (Learning Mathematics for Teaching [LMT], 2008) in Number and Operation Content Knowledge (CK) and Knowledge of Content and Student (KCS) scales were administered to 197 teachers (146 male and 51 female). Two-sample *t* test and multiple regression were conducted to compare the two groups and test the effect of teacher background variables. Female teachers significantly scored better than their male counterpart. Gender, years of teaching experience, and specialization significantly predicted teachers' content knowledge, $F(3, 187) = 13.180$, explaining 41.8 % of the variance. Only gender and specialization significantly predicted teachers' knowledge of content and student, $F(2, 191) = 6.335$, explaining 24.9 % of the variance. Further comparing items in the MKT instrument where female teachers outperformed male teachers confirmed that female teachers were better in attending to the content knowledge in the context of student's learning.

**Keywords** Content knowledge · Gender differences · Knowledge of content and student · Mathematical knowledge for teaching · Pedagogical content knowledge · Saudi Arabia

R. F. Haroun
Princes Nora bint Abdul Rahman University, Riyadh, Saudi Arabia

R. F. Haroun · D. Ng (✉) · F. A. Abdelfattah · M. S. AlSalouli
The Excellence Research Center of Science and Mathematics Education, King Saud University, Riyadh, Saudi Arabia
e-mail: dicky.nang@gmail.com

D. Ng · F. A. Abdelfattah
Qatar University, Doha, Qatar

## Introduction

Student achievement in mathematics continues to be the center of attention in many countries, sparked by results from international comparisons such as the Trends in International Mathematics and Science Study (TIMSS). In TIMSS 2007, Saudi Arabia scored one of the lowest among all participating nations on the achievement sections of the TIMSS. Given the importance and pace of national development in Saudi Arabia, this comparatively low performance by Saudi students becomes a concern for educational policymakers and national development experts in the Kingdom (Wiseman, Sadaawi & Alromi, 2008).

Teachers' mathematical knowledge is one of the key factors in explaining differences in students' achievement in mathematics (Ball, 1990; Ball, Lubienski & Mewborn, 2001; Hill, Ball & Schilling, 2008). Examining the quality of teachers' mathematical knowledge, thus, may provide insights on improving students' achievement (An, Kulm & Wu, 2004; Cai, 2005; Ma, 1999). The focus on the discipline of mathematics in the context of teaching often assumes a universal nature of such knowledge. However, recent efforts to study the cultural dimension of mathematical knowledge for teaching (e.g. Cole, 2012; Delaney, 2012; Fauskanger, Jakobsen, Mosvold & Bjuland, 2012; Kwon, Thames & Pang, 2012; Ng, 2012) have shown variability in what mathematics knowledge teachers need and are expected to know in different countries. Although the focus is on mathematics knowledge, these studies have added cultural and linguistic dimensions to the study of this knowledge. The current proposed study will further our understanding of differences in the mathematics knowledge of teachers in Arabic speaking countries and in the unique context of single-sex classrooms.

The proposed research project will examine gender differences in mathematical knowledge for teaching within the context of Saudi Arabia where the normative practice is predominantly single-sex classroom taught by teachers of the same gender as the students (Hamdan, 2005). The following questions guided the research: *What differences, if any, in mathematical knowledge for teaching exist between male and female teachers in Saudi Arabia?*

## Influence of Teacher's Gender

Gender issue in mathematics education has been studied for over three decades in many countries where male students' achievement in mathematics is significantly higher than female students. However, in some countries, the reverse of the typical gender differences in mathematics achievement is true, that is, female students' achievement in mathematics outranks their male counterparts. More recently, Lindberg, Hyde, Petersen & Linn (2010) in a meta-analysis found that males and females students perform similarly in mathematics. Many factors contributing to the gender differences have been offered including stereotypes of mathematics as a male domain (Greene, Debacker, Ravindran & Krows, 1999), teachers' expectations about their students (Schullo & Alperson, 1998), students' prior experience in the mathematics domain (Seegers & Boekaerts, 1996), and teachers' gender (Burton, 1990). Warwick & Jatoi (1994) argued that in Pakistan, where single-sex classrooms are the norm, teacher gender had a much stronger influence upon the students' mathematics achievement than student gender.

Therefore, a shift from looking into students' gender to teachers' gender may provide more insight into gender differences and mathematics achievement.

In many cases, teacher gender is a significant predictor for student performance because of other contributing factors. For instance, Warwick & Jatoi (1994) show that in single-sex schools in Pakistan, female teachers are often less qualified in mathematics and have comparatively less professional development opportunities as compared to their male counterparts. Furthermore, female teachers tend to lack the confidence to serve as models of successful mathematics learners and typically have lower expectations for female students than for boys, which reflect traditional societal perceptions of gender roles in a male-dominated society (Halai, 2011).

Although teacher's gender has been considered as one of the many teacher variables influencing student learning, studies on the effect of teacher gender on student outcomes have been inconclusive with conflicting results (e.g. Dee, 2006; Krieg, 2005; United Nations Educational, Scientific and Cultural Organization [UNESCO], 2000; Warwick & Haroona, 1994). In a study using data from a longitudinal national database conducted in the USA, Dee (2006) found that same-gender teachers have a positive effect, i.e. when the teachers are the same gender as the students, they tend to perform better than when they are different, which provides support for single-sex classrooms. However, another large-scale study also conducted in the USA shows that regardless of student gender, students taught by female teachers perform significantly better than those taught by their male counterparts (Krieg, 2005). This result is further confirmed by Helbig (2012), who found that boys do not benefit from being taught by male teachers in mathematics and that in some countries girls seem to profit from being taught by female teachers. These conflicting results are shown in developing countries as well. A study in Pakistan (UNESCO, 2000) finds that students in female teachers' classrooms tend to perform better than those who are in male teachers' classrooms. The same case happened in Botswana, where Mwamwenda & Mwamwenda (1989) found that students of female teachers had significantly higher achievement scores in mathematics and other subjects than those taught by male teachers. In contrast, Warwick & Haroona's (1994) results found male teachers' students scoring significantly higher in mathematics than female teachers' students.

Some researchers examined the impact of teacher gender on student attitudes and belief. For instance, Mallam's (1993) study in Nigeria observed that female students who were taught by female teachers have more positive attitudes toward mathematics than their peers who were taught by male teachers. These students tend to perceive themselves to be more able to learn mathematics, and more actively and enthusiastically do so. She attributed this positive effect to not having to compete with their male peers for the teacher's attention, and not having males to discourage them in their mathematics lessons, which improved their motivation to study mathematics. These results were consistent with research done by Lee & Lockheed (1990), who indicated that females who had been taught by female teachers demonstrated more positive attitudes toward mathematics compared to their peers in coed schools, while boys in single-sex schools were negatively affected compared to their peers in coed schools.

Other researchers attributed differences in teaching practices as a plausible explanation to the differential performance of students based on the gender of the teachers (e.g. Carr, Jessup & Fuller, 1999; Chudgar & Sankar, 2008). Chudgar & Sankar's (2008) study in India has shown that male and female teachers differ in terms of their classroom management practices and their beliefs in students' learning ability. Male

teachers are more focused on maintaining discipline compared to their female counterparts. Female teachers, on the other hand, are more likely than male teachers to believe all students' capability in learning mathematics. However, their study does not find any significant evidence on the effect of female teachers' teaching practices on students' mathematics achievement.

One of the challenges in attributing the effect of teacher gender on student achievement in mathematics is the complexity of gender dynamics of the classroom when taking into account the broader context (Chudgar & Sankar, 2008). In addition, societal changes such as gender awareness and stereotypes are rooted in socio-cultural setting that requires a systemic effort over a long period of time (Halai, 2011). For a more immediate and direct change in the classroom, therefore, rather than focusing on larger socio-cultural changes, we shift to examine teacher knowledge, which represents an important predictor of student achievement, because a mathematics teacher's decision making in a class is a function, among others, of teacher's mathematical knowledge (Schoenfeld, 2010). Our stance in looking at the interplay of teacher gender and mathematics for teaching is not meant to be competing with other perspectives on the effect of gender on variables such as attitudes, teaching practices, or gender awareness. Rather, it is to complement these views by limiting the unit of change situated within the classroom by examining differences of gender in the work of teaching mathematics as mediated by the mathematical knowledge for teaching as a plausible explanation to differences in student achievement.

## Mathematical Knowledge for Teaching Framework

One framework of teacher knowledge that has gained momentum in the past decade in the USA is the Mathematical Knowledge for Teaching construct (LMT, 2008). Scholars at the Learning Mathematics for Teaching (LMT) project at the University of Michigan built on Shulman's (1986) theory that teachers need to know both subject matter knowledge and pedagogical content knowledge. They refined these two categories of knowledge into six domains of knowledge. Figure 1 shows the model of this framework. The three domains under subject matter knowledge consist of Common Content Knowledge (CCK), Specialized Content Knowledge (SCK), and Knowledge at the mathematical horizon or Horizon Content Knowledge (HCK). Pedagogical Content Knowledge (PCK) is subdivided into Knowledge of Content and Students (KCS), Knowledge of Content and Teaching (KCT), and Knowledge of Curriculum. CCK refers to mathematical knowledge "used in settings other than teaching" (Ball, Thames & Phelps, 2008, p. 399) and an example would be multiplying two-digit numbers using the standard algorithm. SCK is mathematical knowledge and skill that is "not typically needed for purposes other than teaching" (Ball et al., 2008, p. 400), such as knowing different strategies to multiply two-digit numbers that are more intuitive and make sense for students in the early grades. KCS "combines knowing about students and knowing about mathematics" (Ball et al., 2008, p. 401) and would involve knowing for example the most common errors students make when multiplying two-digit numbers, especially when they apply standard algorithm without understanding. KCT refers to knowledge of mathematics combined with knowledge of teaching and would include knowing how to select what examples to present students with multiplication of two-

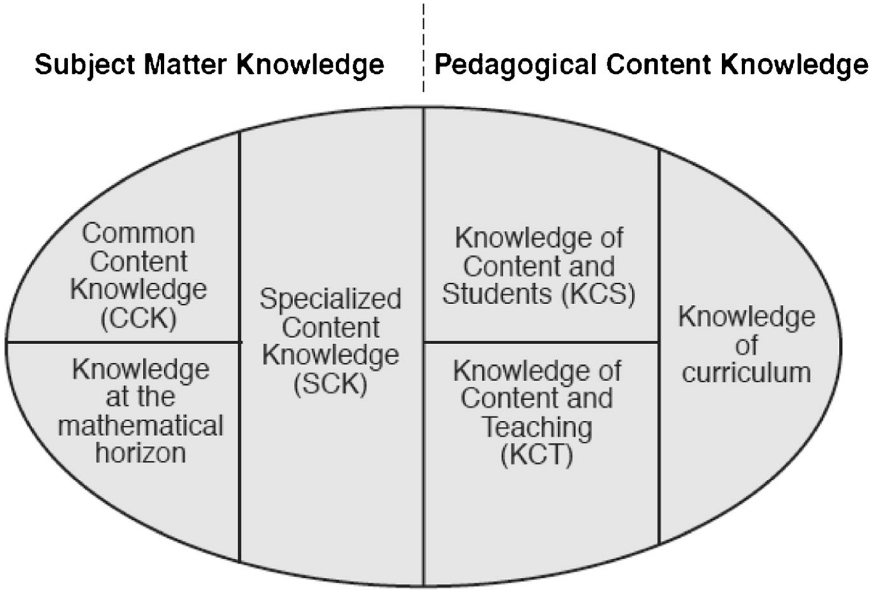


**Fig. 1** Domains of MKT (Ball et al., 2008, p. 403)

digit numbers that will build on their current understanding of multiplication as iterating equal size groups. HCK is "an awareness of how mathematical topics are related over the span of mathematics included in the curriculum" (Ball et al., 2008, p. 403). HCK includes knowledge of the wider discipline of mathematics insofar as its content and practices can inform the work of teaching.

MKT is a practice-based theory (Ball & Bass, 2003) in the sense that it arises from studying the work of teaching practices, which may be cultural in nature (Stigler & Hiebert, 1999). Thus, it is not surprising if nuanced differences may exist to what MKT may look like in different countries (Blömeke & Delaney, 2012). An important feature of the MKT measures is that they are not criterion referenced (Hill, Sleep, Lewis & Ball, 2007), where a set of specific mathematical knowledge need to be specified a priori. Instead, the measures are norm referenced, i.e. teachers are compared to one another based on the different professional knowledge being assessed (Hill et al., 2007). These features of the MKT are what made it attractive for use in countries outside its origin (e.g. Cole, 2012; Delaney, 2012; Fauskanger et al., 2012; Kwon et al., 2012; Ng, 2012). It has the potential to uncover tacit assumptions about teaching mathematics in varying cultural contexts, and the convergence of best practices (Anderson-Levitt, 2012).

## Methods

### Instrument

The Mathematical Knowledge for Teaching (MKT) measures developed by the Learning Mathematics for Teaching (LMT, 2008) were used in this project. The MKT

instruments consist of the following content areas: (a) number concepts and operations (NCOP); (b) geometry; and (c) patterns, functions and algebra (PFA). For this study, the NCOP form B01 was used and consisted of two scales, one on content knowledge (CK) and the other on knowledge of content and student (KCS). The items were intended to represent the knowledge that is vital for teaching primary mathematics. The items were in multiple-choice format with choices ranging from three through seven. The length of each measure varies, but typically participants should not take more than 2 min for each item. The US versions of the instruments have been extensively validated with over 600 primary teachers and the reliabilities are within the range of 0.71 to 0.83 (Hill et al., 2008).

### Items Translation, Adaptation, Validity, and Reliability

The two forms (CK and KCS) were merged into one form (a total of 29 questions) and then translated into Arabic. To ensure validity, the items were not merely translated word-by-word. Instead, double translation (Adams, 2005) was used where two independent translations were made from the source language with reconciliation by a third person such that the items convey the same meaning in the target context, while maintaining integrity to the mathematical content and demand. A pair of researchers with a specialty in mathematics education made two parallel and independent translations. The first researcher holds a bachelor degree in math and a Ph.D. in mathematics education. The second researcher holds a bachelor degree in math and a Ph.D. in assessment and evaluation. Despite the care taken in translating and adapting the instrument, concerns on the validity of the instrument in the new context may require further investigations. However, the purpose of this initial study was not to measure Saudi teachers' mathematical knowledge for teaching in comparison to what they were meant to measure in the original context, but rather an exploration of possible differences in their knowledge by gender. Furthermore, the MKT measures are not criterion referenced, and therefore may be used to compare among the teachers in Saudi for this study. We acknowledge that further research is required in the future to establish the construct validity of the instrument in measuring MKT of Saudi teachers.

Throughout the translation process, all changes made to the items were documented using the categories from Delaney, Ball, Hill, Schilling & Zopf (2008) and Mosvold & Fauskanger (2009). A gender category arose to adapt to the single-sex classroom context in the Saudi Arabia educational system. The two translations were compared and the agreement rate was 85 % between the two translators. Most disagreements were on whether to use Arabic names or to keep the original names as they were in the English version. Reconciliation was made by a third person (the main researcher). The decision was to use Arabic names, and to make two forms of the instrument: one version for male teachers using masculine names, and the another version for female teachers with feminine names. There were no changes in the mathematical content or mathematical demands of the items—the researchers deemed the items are commensurate in the Saudi context. The reliability of the instrument was calculated using Cronbach's alpha, yielding a reliability of 0.74. In general, reliabilities of 0.70 or above are considered adequate for instruments intended to answer research and evaluation questions. This means that the instrument consistently measures the same construct across the sample.

## Data Collection and Analyses

The translated and adapted instrument was administered to a sample of 197 teachers from four main cities in Saudi (Riyadh, Dammam, Abha, and Jeddah). Riyadh is the capital and it is in the center of the country, while Dammam is the east, Jeddah is in the west, and Abha is in the south. The number of male teachers was higher ($N = 146$) than female teachers ($N = 51$) because of the difficulties the researchers faced to distribute the instrument in girls' schools. Access to girls' schools is usually very hard for male personnel or researchers in Saudi due to cultural norms. Data on the background of the teachers (teaching experience, specialty, qualification/degree, teaching certificate, and training/professional development hours) was also collected (see Table 1).

The raw scores of the participants were converted to IRT scores ($IRT_{CK}$ and $IRT_{KCS}$), which were linear and in standard deviation units. An IRT score of 0 is the mean, and shows that a participant performs at an average level. A positive IRT score is interpreted that the participant performs above average, and likewise a negative IRT score is interpreted that the participant performs below average. The data was analyzed to compare between male teachers and female teachers' mathematical knowledge for

**Table 1** Descriptive statistics on teacher background

| Category | Value | Frequency | | |
|---|---|---|---|---|
| | | Total<br>197 | Male<br>146 | Female<br>51 |
| Area | Riyadh | 97 | 96 | 1 |
| | Dammam | 49 | 0 | 49 |
| | Jeddah | 1 | 0 | 1 |
| | Abha | 50 | 50 | 0 |
| Teaching experience | Less than 3 years | 16 | 10 | 6 |
| | 3–5 years | 42 | 30 | 12 |
| | 6–8 years | 31 | 25 | 6 |
| | More than 8 years | 104 | 77 | 27 |
| Specialty | Math | 144 | 115 | 29 |
| | Science | 28 | 15 | 13 |
| | Other | 22 | 14 | 8 |
| Qualification/degree | Diploma | 38 | 22 | 16 |
| | Bachelor | 142 | 114 | 28 |
| | Masters | 12 | 8 | 4 |
| | Other | 2 | 0 | 2 |
| Teaching certificate of degree | Yes | 186 | 140 | 46 |
| | No | 9 | 5 | 4 |
| Training | No | 30 | 25 | 5 |
| | One workshop | 30 | 23 | 7 |
| | Two workshops | 46 | 39 | 7 |
| | Three or more workshops | 87 | 56 | 31 |

teaching using independent two-sample *t* test. Analyses of variances (ANOVAs) were conducted to examine whether they were significant differences between groups by years of teaching experience, specialty (math, science, or other), qualification/degree (diploma, bachelor, master, or other), teaching certification, and number of professional development/training taken.

## Results

Overall, the Saudi teachers performed about one standard deviation in both content knowledge ($M_{CK}$ = −1.03, SD = 0.75) and knowledge of content and student ($M_{KCS}$ = −1.25, SD = 0.73) below their counterpart from the USA where the items were piloted as shown by the negative score. When broken down by genders, there is a difference of means for content knowledge ($IRT_{CK}$) between male (*M* = −1.11, SD = 0.74) and female (*M* = −0.81, SD = 0.73), favoring female teachers. The same is true for knowledge of content and student ($IRT_{KCS}$) where female teachers (*M* = −1.08, SD = 0.77) slightly outperformed their male counterpart (*M* = −1.31, SD = 0.70). Results from the independent two-sample *t* test showed significant differences by gender in content knowledge, $t(195) = 0.29$ standard deviation points, $p = 0.015$, and knowledge of content and students, $t(195) = 0.23$ standard deviation points, $p = 0.05$, with female receiving higher scores than male. Although the sample sizes of the two groups by gender are different, Levene's test for equality of variances showed no significant differences in variances between the two groups' content knowledge scores ($p = 0.94$) and knowledge of content and student scores ($p = 0.36$) (Table 2).

A multiple regression was run to predict IRTCK and IRTKCS from gender, specialization, years of teaching experience, teaching certificate, educational major, and training (professional development). From these variables, only the gender, years of teaching experience, and specialization significantly predicted IRTCK, $F(3, 187) = 13.180$, $p < 0.0005$, $R^2 = 0.175$. These three variables added statistically significantly to the prediction, $p < 0.005$. These three predictors explained 41.8 % of the variance. Only gender and specialization significantly predicted IRTKCS, $F(2, 191) = 6.335$, $p = 0.002$, $R^2 = 0.062$. These two variables added statistically significantly to the prediction, $p = 0.006$. These two predictors explained 24.9 % of the variance (Tables 3 and 4).

In comparing how the two groups performed on each item (using a cutoff point difference of 20 % or more), female teachers outperformed their male counterpart in six

**Table 2** IRTCK and IRTKCS means for males and females

| | Gender | | *t* | *df* |
|---|---|---|---|---|
| | Male | Female | | |
| IRTCK | −1.106 (0.741) | −0.812 (0.725) | −2.449* | 195 |
| IRTKCS | −1.312 (0.703) | −1.081 (0.772) | −1.974* | 195 |

*$p \leq 0.05$. Standard deviations appear in parentheses below the means

**Table 3** Coefficients variables resulting from multiple regression analysis for IRTCK

| | Unstandardized coefficients | | Standardized coefficients | *t* | Sig. |
|---|---|---|---|---|---|
| | *B* | Std. error | Beta | | |
| Constant | −1.494 | 0.235 | | −6.362 | 0.000 |
| Year of teaching experience | 0.149 | 0.048 | 0.207 | 3.109 | 0.002 |
| Specialization | −0.345 | 0.074 | −0.318 | −4.699 | 0.000 |
| Gender | 0.382 | 0.114 | 0.227 | 3.353 | 0.001 |

items, while male teachers performed better in three items. Majority of the items where the female teachers performed better than the male teachers were from the KCS scale as shown in Table 5.

To illustrate the kind of questions asked in the KCS scale where the female teachers performed significantly better than the male teachers, we provided an abridged version of the items as examples below:

> Question 21 asked the teachers to make sense and evaluate the validity of a student's invented algorithm to a multiplication problem as shown below in Fig. 2: Question 25 required teachers to identify the error students made when multiplying two mixed numbers $5\frac{1}{4}$ and $3\frac{1}{3}$, where the students responded with an answer of 16. One of the students' explanation was: "I just multiply 5 times 3, which is 15, and then I need to find a common denominator for the others, which would be twelfths. So I had $\frac{3}{12}$ and $\frac{4}{12}$, and 3 × 4 is 12, which is $\frac{12}{12}$, and that is the same as 1, so I add 1 to 15."

Figure 3 shows item Question 27 that asked teachers to evaluate a student's explanation to multi-digit subtraction as shown below: "You can't take 7 from 6, so you cross out the 0 and make it a 9, and the 6 becomes a 16, and then cross out the 3 and it becomes a 2. Then I take away. 16 take away 7 is 9, 9 take away 9 is 0, and you just have 2."

Figure 4 shows item Question 28, which required teachers to conduct error assessment on subtraction problems as shown below to identify common errors students make.

**Table 4** Coefficients variables resulting from multiple regression analysis for IRTKCS

| | Unstandardized coefficients | | Standardized coefficients | *t* | Sig. |
|---|---|---|---|---|---|
| | *B* | Std. error | Beta | | |
| Constant | −1.285 | 0.172 | | −7.465 | 0.000 |
| Specialization | −0.229 | 0.076 | −0.216 | −3.027 | 0.003 |
| Gender | 0.281 | 0.118 | 0.170 | 2.390 | 0.018 |

**Table 5** Description of items with significant differences in performance

| | Description | Scale | % Correct | | |
|---|---|---|---|---|---|
| | | | Total | Male | Female |
| Q13a | Patterns in a 100 s chart | KCS | 61.9 | 67.1[a] | 47.1 |
| Q14 | Estimating a product of a whole number and a decimal less than 1 | KCS | 51.8 | 58.2[a] | 33.3 |
| Q18a | Assessing generality of "rules of thumb" | CK | 54.3 | 61.6[a] | 33.3 |
| Q18d | Assessing generality of "rules of thumb" | CK | 64.5 | 57.5 | 84.3[a] |
| Q21 | Making sense of student's strategy in multiplying multi-digit whole numbers | KCS | 43.7 | 37.0 | 62.7[a] |
| Q22 | Explaining student error in a mathematical equality | KCS | 48.2 | 39.7 | 72.5[a] |
| Q25 | Recognizing error in multiplying two mixed numbers | KCS | 53.3 | 46.6 | 72.5[a] |
| Q27a | Evaluating student's explanation for subtracting multi-digit whole numbers | KCS | 40.1 | 34.9 | 54.9[a] |
| Q28 | Error assessment in subtraction of multi-digit whole numbers | KCS | 62.9 | 56.2 | 82.4[a] |

[a] Denotes 20 % or more answered the item correctly compared to the other gender

## Discussion

The low mean scores in both content knowledge and knowledge of content and student suggest that teachers' mathematical knowledge for teaching may be a contributing factor (Ball, 1990; Ball et al., 2001; Hill et al., 2008) to low students' achievement in TIMSS. Dodeen, Abdelfattah, Shumrani & Abu Hilal (2012) compared mathematics teachers' qualifications, practices, and perceptions between Saudi and Taiwanese schools using responses of mathematics teachers to the Teacher Background Questionnaire—8th Grade from the Trends in International Mathematics and Science Study (TIMSS) in 2007. They found significant differences in teachers' preparation for teaching specific mathematics topics and the quality of professional development programs between the two countries, more favorable for Taiwanese teachers. Moreover, their results showed that teachers' qualifications and practices were related to students' scores. It came as no surprise, therefore, that in our study, we found the teachers to score more than one standard deviation point below the US sample.

Teaching experience and specialization in mathematics have a positive effect on teachers' content knowledge, but not on knowledge of content and student

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  983
 x  6
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+5410
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 5898
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**Fig. 2** Sample item in evaluating the validity of student's invented algorithm in multi-digit multiplication

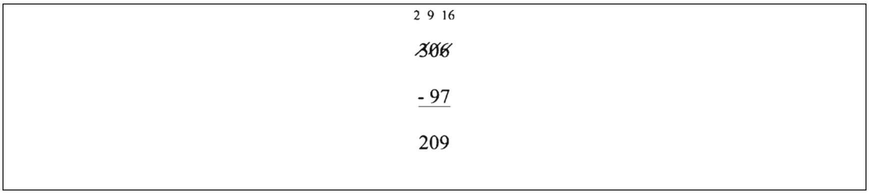


**Fig. 3** Sample item to evaluate student's explanation to multi-digit subtraction

(pedagogical content knowledge). The main difference is between teachers who have taught between 3 and 5 years with teachers who have taught between 6 and 8 years. Teachers become more experience and familiar with the content they teach over time, especially if they have the opportunity to teach multiple grade levels (Ng, 2011). However, when it relates to pedagogical content knowledge, the results suggest that teaching experience alone does not improve teachers' knowledge of content and student (Ball et al., 2008; Shulman, 1986). Developing this specific knowledge requires attention to student learning rather than a disciplinary knowledge. However, specializing in mathematics has an interacting effect on KCS since teachers who are more facile with the content knowledge allows them access to develop KCS as they interact with students over time and notice patterns of behaviors, errors, and strategies.

In the context of single-sex classroom in Saudi, differences between male and female teachers' mathematical knowledge is of particular interest because it may explain differences in students' performance by gender, where girls outperformed boys (e.g. result from 2007 TIMSS, see Gonzales et al., 2008). This difference is in contrast to typical coed classrooms where boys perform better than girls because teachers pay more attention to them since boys are more active in showing their knowledge of the subject they are studying, and they are the ones who often raise their voices during class (Hamdan, 2005). Female teachers in this study scored significantly higher than their male counterpart in both CK and KCS. Interestingly, the effect of teaching experience on CK is no longer significant when looking at female teachers. This result suggests that the female teachers may have stabilized in their content knowledge earlier than the male teachers, plausibly during their preparation program. More research is needed to explain this phenomenon.

A study of prospective primary teachers from 15 countries that participated in Teacher Education and Development Study: Learning to Teach Mathematics (TEDS-M) shows significant differences in mathematics content knowledge in favor of male compared with female teachers in most countries, but the gender effect did not apply to the same extent to mathematical pedagogical content knowledge, and in some countries, female teachers outperformed male teachers (Blömeke, Suhl & Kaiser, 2011).

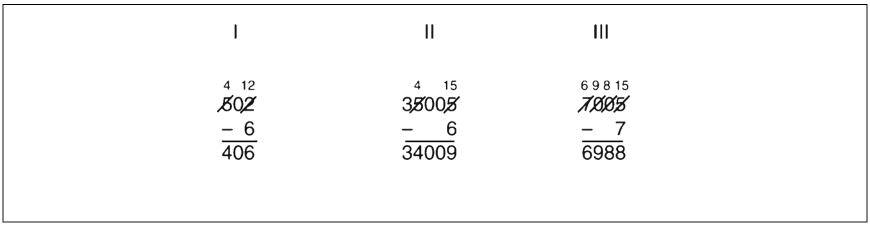


**Fig. 4** Sample item in student error analysis in subtraction problems

Blömeke & Delaney (2012) attribute this effect to female future teachers more prone to support pedagogical moves than male future teachers do. This effect is particularly noteworthy in this study with practicing teachers, when examining how the two gender groups performed on KCS items. Female teachers were more successful than male teachers in answering questions from the KCS scale as shown earlier in Table 5. These are questions that asked teachers to make sense of student's strategies in solving problems, recognizing and explaining student's errors, and evaluating the validity of student's mathematical explanation. As Blömeke & Delaney (2012) pointed out for prospective teachers, it seems that the female teachers in Saudi were more attentive to students' reasoning, strategies, and errors, rather than simply understand the content from a disciplinary point of view. They were more likely to understand the content from the perspective of the learners, and appropriate mathematical tasks and instructions to support their mathematical development.

These results may partially explain why female students in Saudi outperformed their male peers. Although content knowledge is absolutely crucial in teaching, it is pedagogical content knowledge that allows teachers to reach their students and support their development of understanding. One implication from this study, therefore, is to rethink what male teachers need in their professional development, so that targeted effort on what would impact their practice.

## Conclusion

The importance of improving teachers' mathematical knowledge for teaching cannot be undermined if we want to improve students' performance, especially in the context of international comparative studies such as TIMSS. As shown in this study, the overall knowledge of teachers in this sample showed significantly low content knowledge and knowledge of content and student, which suggests the urgency for improving teacher education program and providing targeted quality professional development opportunities for teachers in Saudi. Reliance solely on teaching experiences may not impact teachers' development of the kind of knowledge that is useful in improving students' achievement (Hill, Rowan & Ball, 2005), especially when it comes to pedagogical content knowledge (PCK).

Zahrani & Jones (2013) reported data from a study of primary mathematics teacher preparation in the Kingdom of Saudi Arabia on the opportunity to learn (OTL) that preservice primary mathematics teachers receive on school-level mathematics. They found that preservice primary teachers received only moderate opportunity to learn the mathematical topics that they needed for their teaching, particularly in some topics such as algebra. It is imperative to examine the teacher preparation program in Saudi to make sure that preservice teachers do have the opportunity to learn not only content knowledge they will teach, but also PCK that shifts attention on student learning rather than simply disciplinary knowledge.

Although professional development or training was not a significant effect on teachers' mathematical knowledge in this study, it remains a vital venue for teachers' continuing learning on the job. What is required is to refocus professional training from merely content knowledge to knowledge of content and student. Moreover, more

targeted efforts should be made to provide professional development to meet the needs of the teachers based on their gender.

The result of this study is an initial attempt to uncover the possibility of teachers' mathematical knowledge as one plausible explanation for gender differences in students' achievements in mathematics to target teacher preparation programs. More research is needed to provide further explanations and include more representative samples to arrive at more robust causality effect.

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